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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/567,733	02/10/2006	Kohei Kawamura	285995US26PCT	7700

22850 7590 04/08/2009  
OBLON, SPIVAK, MCCLELLAND MAIER & NEUSTADT, P.C.  
1940 DUKE STREET  
ALEXANDRIA, VA 22314

EXAMINER
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PARENDO, KEVIN A

ART UNIT	PAPER NUMBER
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2823

NOTIFICATION DATE	DELIVERY MODE
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04/08/2009

ELECTRONIC

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

patentdocket@oblon.com  
oblonpat@oblon.com  
jgardner@oblon.com

<b>Office Action Summary</b>	<b>Application No.</b> 10/567,733	<b>Applicant(s)</b> KAWAMURA ET AL.	
	<b>Examiner</b> Kevin Parendo	<b>Art Unit</b> 2823	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 27 January 2009.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-17 is/are pending in the application.
- 4a) Of the above claim(s) 13, 16 and 17 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-12, 14 and 15 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 10 February 2006 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All    b) ☐ Some \*    c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)            | 4) <input type="checkbox"/> Interview Summary (PTO-413)           |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | Paper No(s)/Mail Date. _____                                      |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date <u>8/2/07 and 2/8/08</u> .                                       | 6) <input type="checkbox"/> Other: _____                          |

## **DETAILED ACTION**

### ***Election/Restrictions***

1. Applicant's election without traverse of group I, in the reply filed on 1/27/09 is acknowledged. Claims 1-17 are pending. Claims 1-12 and 14-15 that read on the elected embodiment will be examined.

### ***Drawings***

2. Figure 1 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated. See MPEP § 608.02(g). Corrected drawings in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

### ***Specification***

3. The title of the invention is not descriptive. A new title is required that is clearly indicative of the invention to which the claims are directed.

The following title is suggested: Fluorine doped carbon films produced by modification by radicals.

4. The abstract of the disclosure is objected to because it contains the phrase "comprise." The form and legal phraseology often used in patent claims, such as "means" and "said," should be avoided. The phrase should be changed to "includes." Correction is required. See MPEP § 608.01(b).

### ***Claim Objections***

3. Claim(s) 1 is/are objected to because it/they contain(s) the limitation "said source gas molecule" on line 9. This limitation has not been claimed previously to this instance and thus lacks proper antecedent basis. Appropriate correction is required.

4. Claim(s) 4 is/are objected to because the word "a" should be inserted before "microwave plasma".

5. Claim(s) 8 is/are objected to because it/they contain(s) the limitation "a source gas" on line 3. This limitation has been claimed previously to this instance and thus lacks proper antecedent basis. To avoid any ambiguity, the word "a" should be changed to "the".

6. Claim(s) 10 is/are objected to because it/they contain(s) the limitation "CF ratio" that should be changed to "F/C ratio" to match the language of the other terms and that of the last two line of claim 10.

7. Claim(s) 12 is/are objected to because it/they contain(s) the limitation "a first and second processing chambers", from which the "a" should be deleted.

***Claim Rejections - 35 USC § 102***

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claims 1, 2, 3, 6, and 7 are rejected under 35 U.S.C. 102(b) as being anticipated by Jiwari et al. (US 2003/0025209 A1, hereinafter "Jiwari").

**Re claim 1**, Jiwari discloses a film forming method, comprising the steps of:

- forming a F-doped carbon (paragraph 4) film **107** (paragraph 41 and Fig. 2C) by using a source gas containing C and F (paragraphs 9 and 40); and
- modifying said F-doped carbon film by radicals (this modification occurs during the film formation, see paragraphs 44-47; alternatively, film **108** of Fig. 2D may be the F-doped carbon film instead of the indicated film **107**, above, and it is modified by Ar plasma as described in paragraphs 58-59; it is well known that a plasma consists of charged electrons, ions, and molecules, and that radicals are formed when the charged electrons strike molecules),

- said source gas having a F/C ratio, defined as a ratio of a number of F atoms to a number of C atoms in said source gas molecule, wherein said F/C ratio is larger than 1 but smaller than 2 (paragraphs 9, 40, and 58, wherein the F/C ratio is 8/5 for  $C_5F_8$  or 6/4 for  $C_4F_6$ ).

**Re claim 2**, Jiwari further discloses that said modifying step is conducted so as to remove F atoms (circled "F" atoms in Fig. 4A are free and unbonded, and these are "removed" by bonding them with C atoms as shown in Fig. 4B) terminating an exposed surface (the process results in fewer free F atoms near the surface, see Fig. 4B, thus the surface is more completely terminated with F atoms) of said F-doped carbon film.

**Re claim 3**, Jiwari further discloses that said modifying step is conducted in radicals containing any of N, Ar (paragraphs 40, 45-46, and 58, wherein Ar is a constituent of the plasma so some Ar molecules will be formed into radicals), Kr, C (paragraphs 40 and 45-46, wherein the CF gases are dissociated into radicals), B and Si.

**Re claim 6**, Jiwari further discloses that said source gas comprises any of  $C_3F_4$ ,  $C_4F_6$  and  $C_5F_8$  (paragraph 9).

**Re claim 7**, Jiwari further discloses that said source gas is free from a hydrogen gas component (paragraphs 9 and 40; the CF gases do not contain H; furthermore, hydrogen is not used in the plasma at all, since only CF, Ar, and CO gases are used, see paragraph 52).

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9. Claims 1, 6, 7, and 8 are rejected under 35 U.S.C. 102(b) as being anticipated by Sugahara et al. (US 5,989,998, hereinafter "Sugahara").

**Re claim 1**, Sugahara discloses a film forming method, comprising the steps of:

- forming a F-doped carbon film ("fluorinated amorphous carbon film", column 4, lines 26-27) by using a source gas containing C and F ( $C_4F_6$ , see at least chemical formulas 3 and 4, in column 14; and column 13, line 66 – column 14, line 38); and
- modifying said F-doped carbon film by radicals (this modification occurs during the film formation, since radicals are formed due to decomposition in the plasma, see column 14, line 19),
- said source gas having a F/C ratio, defined as a ratio of a number of F atoms to a number of C atoms in said source gas molecule, wherein said F/C ratio is larger than 1 but smaller than 2 ( $C_4F_6$  has a ratio of 6/4).

**Re claim 6**, Sugahara further discloses that said source gas comprises any of  $C_3F_4$ ,  $C_4F_6$  and  $C_5F_8$  ( $C_4F_6$ ).

**Re claim 7**, Sugahara further discloses that said source gas is free from a hydrogen gas component ( $C_4F_6$  does not contain hydrogen, see column 14, line 36).

**Re claim 8**, Sugahara further discloses that said F-doped carbon film is formed of a plasma CVD process (column 7, line 36) that uses a source gas containing C and F ( $C_4F_6$ ).

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

10. Claims 4 and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Jiwari, as applied to claim 1, above, and further in view of Hongo et al. (US 2002/0046808 A1, hereinafter "Hongo").

**Re claims 4 and 5**, Jiwari discloses the limitations of claim 1, as discussed above, but fails to further disclose that said radicals are excited by microwave plasma (as pertains to claim 4), and that said microwave plasma is formed by introducing a microwave into a processing space in which said F-doped carbon film is formed by a planar microwave antenna via a microwave window that forms said processing space (as pertains to claim 5).

Hongo discloses exciting a microwave plasma (paragraph 15), and that said microwave plasma is formed by introducing a microwave into a processing space (S, Fig. 1) in which a film is formed (on wafer W, see paragraph 7 and Fig. 1) by a planar microwave antenna **76** (paragraph 61 and Fig. 1) via a microwave window (paragraphs 17 and 63) that forms said processing space.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to add the invention of Hongo to the invention of Jiwari. The motivation to do so is that the combination produces the predictable results of forming the plasma using microwave frequencies in a low vacuum (paragraph 4) with improved



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planar uniformity of the plasma (paragraph 10) to assist in chemical vapor deposition (paragraph 36).

11. Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sugahara, as applied to claim 8, above, and further in view of Hongo et al. (US 2002/0046808 A1, hereinafter "Hongo").

**Re claim 9**, Sugahara discloses the limitations of claim 8, as discussed above, but fails to further disclose that said plasma CVD process is conducted by dissociating said source gas by microwave plasma. Hongo discloses a plasma CVD process (paragraph 36) is conducted by dissociating a source gas by microwave plasma (paragraphs 15 and 16). It would have been obvious to one of ordinary skill in the art at the time the invention was made to add the invention of Hongo to the invention of Sugahara. The motivation to do so is that the combination produces the predictable results of forming the plasma using microwave frequencies in a low vacuum (paragraph 4) with improved planar uniformity of the plasma (paragraph 10) to assist in chemical vapor deposition (paragraph 36).

12. Claims 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sugahara in view of Subrahmanyam et al. (US 6,107,192).

**Re claim 10**, Sugahara discloses a method of fabricating a semiconductor device, comprising the steps of:

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- depositing a F-doped carbon (“fluorinated amorphous carbon film”, column 4, lines 26-27) film **202** or **204** (see Fig. 3B) on a substrate by a plasma CVD (column 7, line 36) process that uses a source gas that contains C and F in a molecule thereof ( $C_4F_6$ , see at least chemical formulas 3 and 4, in column 14; and column 13, line 66 – column 14, line 38);
- forming an opening **205** (Fig. 3B) in said F-doped carbon film by a dry etching process (oxygen plasma) of said F-doped carbon film; and
- said source gas having a CF ratio, defined as a ratio of a number of F atoms to a number of C atoms in said source gas molecule, wherein said F/C ratio is larger than 1 but smaller than 2 ( $C_4F_6$  has a ratio of 6/4).

Re claim 10, Sugahara fails to disclose covering a sidewall surface and a bottom surface of said opening by a metal film, and that there is provided, after said step of forming said opening but before said step of covering said sidewall surface and bottom surface of said opening by said metal film, a step of modifying at least said sidewall surface of said opening by radicals.

Subrahmanyam discloses (see column 3, lines 1-26) covering a sidewall surface and a bottom surface of said opening by a metal film (“barrier/liner layer”), and that there is provided, after said step of forming said opening (“contact holes”) but before said step of covering said sidewall surface and bottom surface of said opening by said metal film, a step of modifying at least said sidewall surface of said opening by radicals (“hydrogen radicals”).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to add the invention of Subrahmanyam to the invention of Sugahara. The motivation to do so is that the combination produces the predictable results of precleaning oxides and etch residues from the bottom and sidewalls of contact holes, before the formation of metal barrier layers (column 3, lines 1-26).

13. Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sugahara and Subrahmanyam, as applied to claim 10, above, and further in view of Kao et al. (US 2001/0042513 A1, hereinafter "Kao").

**Re claim 11**, Sugahara and Subrahmanyam disclose the limitations of claim 10, but Sugahara fails to further disclose that said radicals in said modifying step are excited by microwave plasma. Kao discloses radicals that are excited by a microwave plasma (paragraph 6). It would have been obvious to one of ordinary skill in the art at the time the invention was made to add the invention of Kao to the inventions of Sugahara and Subrahmanyam. The motivation to do so is that the combination produces the predictable results of generating radicals more efficiently by using microwave radiation than by the use of RF radiation (paragraph 6).

14. Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Sugahara and Subrahmanyam, as applied to claim 10, above, and further in view of Kumar et al. (US 2003/0084587 A1, hereinafter "Kumar").

**Re claim 12**, Sugahara and Subrahmanyam disclose the limitations of claim 10, as discussed above, and Sugahara further discloses that said step of depositing said F-doped carbon film further comprises a step of forming a hard mask film **203** (Fig. 3A) on a surface of said F-doped carbon film **202** (Fig. 3A), but fails to further disclose that:

- said step of depositing said F-doped carbon film and said step of forming said hard mask film are conducted respectively in a first and second processing chambers coupled to a first vacuum transfer chamber, and
- said step of forming said opening and said step modifying step being conducted respectively in third and fourth processing chambers coupled to a second vacuum transfer chamber.

Kumar discloses an apparatus **10** (Fig. 1) consisting of a substrate transfer chamber **16** and first through fourth processing chambers **18**, **20**, **22**, and **24** (Fig. 1). Kumar teaches performing each process of the process flow in a different chamber, for instance, etching a via **104** in the first chamber, forming an adhesion layer **106** in the second chamber, forming a barrier layer **108** on the sidewalls in the third chamber, and depositing the plug **110** in the fourth chamber (paragraphs 34-37). It would have been obvious to one of ordinary skill in the art, given the teachings of Kumar, to perform the recited steps in the different recited chambers. The motivation to do so is that the chambers are coupled to each other and separated from the environment, and thus allow for the processing to be performed without contaminating the film by the ambient environment (paragraphs 31-32).

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15. Claims 14 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ito et al. (US 2003/0116854 A1, hereinafter "Ito") in view of Sugahara.

**Re claim 14**, Ito discloses a method of fabricating a semiconductor device, comprising the steps of:

- depositing a fluorine-doped carbon film **14** (paragraph 48 and Fig. 9) on a substrate **24** (paragraph 48 and Fig. 9);
- forming an opening (area filled by 26 and 19, which is said in paragraph 88 to be formed by the same processes as in previous embodiments, so the opening is analogous to that described in paragraph 81) in said fluorine-doped carbon film by a dry etching process (RIE, reactive ion etching, is a dry etching process, paragraph 81); and
- depositing a first metal film **19/23** (paragraphs 82, 88, and Fig. 9; both 23 and 19 are said to be formed of Al) so as to cover a sidewall surface and a bottom surface of said opening,
- wherein there is provided, after said step of forming said opening but before said step of depositing said first metal film, a step of depositing a second metal film (paragraph 82, wherein an Al film is deposited) that forms a stable compound when reacted with F (Aluminum is said to be such a film, see the applicant's specification in paragraphs 127 and 129 of published application), such that said second metal film covers at least said sidewall surface and bottom surface of said opening (Fig. 9).

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Re claim 14, Ito fails to disclose that the fluorine-doped carbon film is formed by a plasma CVD process that uses a source gas that contains C and F in a molecule thereof. Sugahara discloses that a fluorine-doped carbon film ("fluorinated amorphous carbon film", column 4, lines 26-27) is formed by a plasma CVD process (column 7, line 36) that uses a source gas that contains C and F in a molecule thereof ( $C_4F_6$ , see at least chemical formulas 3 and 4, in column 14; and column 13, line 66 – column 14, line 38). It would have been obvious to one of ordinary skill in the art at the time the invention was made to add the invention of Sugahara to the invention of Ito. The motivation to do so is that the combination produces the predictable results of forming a fluorine-doped carbon film through a plasma process that results in a highly-crosslinked film that has an increased glass transition temperature and improved heat resistance (column 4, lines 28-39).

**Re claim 15**, Ito further discloses that said second metal film is selected from a group consisting of Al, Ru, Ni, Co, Pt, Au and Ag (paragraph 82, wherein Al is formed, and then oxidized).

### ***Conclusion***

16. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kevin Parendo, whose can be contacted by phone at (571) 270-5030 or directly by fax at (571) 270-6030. The examiner can normally be reached on Mon.-Thurs. and alternate Fridays from 7 a.m. - 4:30 p.m. EST.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Smith, can be reached on (571) 272-1907. The fax number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Kevin A. Parendo/  
Examiner, Art Unit 2823  
4/6/2009

/Hsien-ming Lee/  
Primary Examiner, Art Unit 2823